Lunar Wave Interpretations

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Introduction

I have recently been reviewing over 20 lunar wave videos to get data for scientific analysis of the lunar wave phenomenon.

As a pattern, in the week immediately before and immediately after the full Moon and in the early evening when amateur astronomers are actively video recording the Moon, a double wave phenomenon has been observed on multiple occasions. The pair of waves appear to race at up to 1650 km/sec from one lunar polar region to the other polar region. The time between waves is 0.7 to 40 seconds, and the transit times across the lunar surface vary from 2.1 to about 160 seconds.

In most cases, the pairs of waves are very straight as seen from Earth and the pair travels at nearly the same speed and angle across the lunar disc. The direction of travel varies with each occasion, but is typically north to south. Travel speed appears constant across the disc (no slowing down or speeding up at the poles or equator).

As an important observation, the background image of craters or celestial objects shifts slightly in the direction of wave travel as each wave passes by.

The phenomenon does not appear to be luminous as compared with the Moon, with the video technology commonly employed to record such events. It means the waves are currently only detected when seen against a well-lit background, such as provided by the Moon or a planet such as Jupiter or Saturn.

Observations outside of the visual spectrum are lacking. Infrared and radio astronomy may offer additional clues as to the origins and mechanisms involved.

In Part 1 below, I present scientific theories to explain the lunar wave phenomenon. In Part 2, I derive a practical experiment to verify the speed and altitude of the waves. As a theme, I aim to show how scientific methods can help discover the origin and describe the mechanisms of the lunar waves.

PART 1 – Scientific Theories for the Lunar Waves

Two Worlds, Two Wave Sets

1) The 26 September 2012 lunar wave sighting by CRROW 777 is the earliest known recording, Fig. 1. After careful analysis by CRROW, it appears there were two wave events occurring simultaneously.
   https://youtu.be/_3axPn65MGM?si=cd1HxgAep9woWlxk

   https://www.youtube.com/watch?v=iMQTEEbtTYc&pp=ygUfU29tZSBGYWN0cyBBYm91dCBUaGUgTHVuYXIgV2F2ZQ%3D%3D

2) The first event was actually a curved wave pair apparently located on the Moon. He described

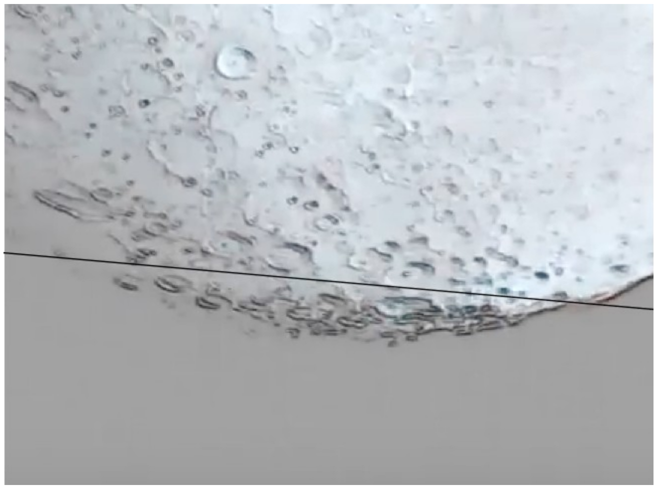

Fig. 1 A magnified still frame from the September 26, 2012 lunar wave video of CRROW 777, with image filters and angled line applied to enhance visibility.

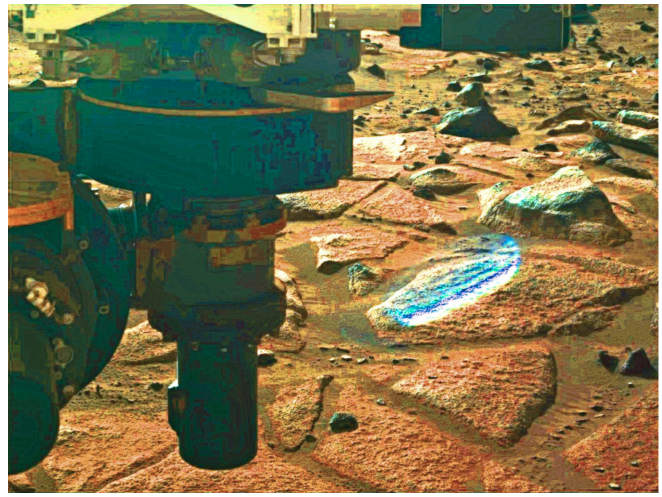

Fig. 2 A mysterious glowing blue transparent glass fragment was photographed by the Perseverance rover in Jezero crater on Mars. (photo: NASA, https://www.theothersideofmidnight.com/wp-content/uploads/2024/01/Percy-Prism-enhanced-saturated-scaled.jpg)

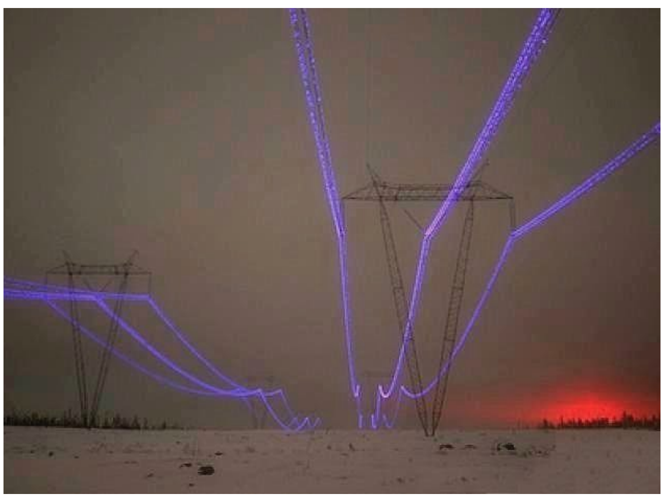

Fig. 3 A corona effect occurs near high voltage installations on Earth, although less bright than on Mars due to the denser atmosphere (photo: https://www.allumiax.com/blog/what-is-the-corona-effect-in-transmission-lines-how-engineers-overcome-it)

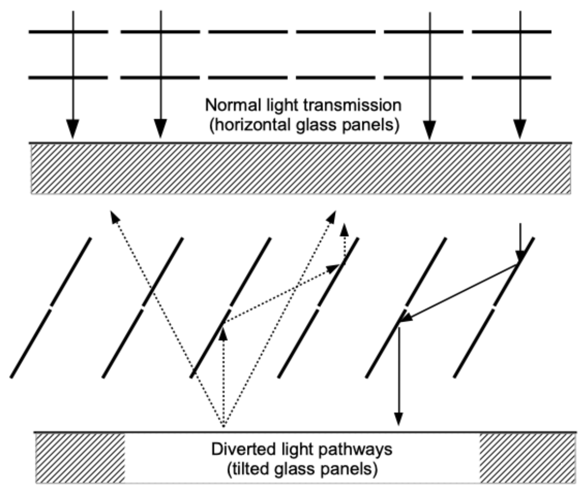

Fig. 4 A tilting glass panel mechanism to explain the lunar wave effects.

the pair as an "energy pulse" and noted their unique curved shape. I currently interpret them as due to an electromagnetic response by the ancient glass ruins on the Moon to a planetary alignment. I regard CRROW's data as independent confirmation of the existence of the ruins.

3) The second event, occurring simultaneously, was a straight pair of waves moving across the entire face of the Moon, apparently at about the same 200 miles per second speed as the curved pair. I currently interpret them as occurring in the atmosphere of Earth in response to the same planetary impulse.

From item 2), the only reasonable explanation for curved waves is that they were closely related to the spherical lunar surface. That is precisely the location where the ancient glass ruins exist that once comprised a lunar dome.

Given that waves of any sort must exist in a medium, the glass would provide the optical qualities necessary for an Earth-based observer to see the wave effect. The two primary qualities are refraction and reflection. The first occurs for light rays impinging the glass at less than the angle of refraction of 56 degrees and so can pass through the glass. The second occurs when the incoming light rays are more than 56 degrees away from the surface normal and so are reflected away in mirror-like fashion.

As a further observation, the curved waves seemed to emerge from the lunar south pole and appeared stronger there. They disappeared as they progressed towards the lunar equator.

The first reason for this is that the angle of observation moved below the 56 degree angle required for reflection from the glass.

A second reason is because the ancient dome is less disturbed at the lunar poles, while there are major gaps in the ancient and degraded glass superstructure in the equatorial regions. We know this because all lunar missions landing away from the poles did not encounter the glass. Only the recent missions attempting to land near the poles encountered enough glass to cause bizarre equipment failures.

From the timing of item 3), the curved wave pair would appear to be be the lunar response to the same trigger that caused the simultaneous terrestrial wave pair. It implies the ancient lunar dome was engineered to respond in similar fashion to cosmic trigger pulses as the upper atmosphere of Earth.

In a January 30, 2024 email to Richard Hoagland, I inferred from the glowing image of a glass fragment in Jezero crater on Mars, Fig. 2, that the ancient glass was engineered to have powerful electrical properties, Fig. 3.

In a March 4, 2024 email, I proposed a tilted glass panel mechanism, arranged in multiple layers at some height above the lunar surface, that would explain both the rapid wave movement and the optical image shift of lunar craters lying beneath the glass, Fig. 4.

On March 6, 2024, Hoagland counter-proposed that a sufficiently advanced electro-optics technology could create the necessary change in the glass index of refraction without mechanical means (“VERY clever ... these ETS.”)

The Waves are in the Air

The reasons I currently believe the straight pairs of waves are located in Earth's atmosphere are:

4) The degraded lunar glass dome would not be able to support waves crossing the full diameter of the Moon. However, a number of videos show that almost the full face of the Moon is transited by the wave pair with no obvious gaps.

5) The straightness of the waves is because they are relatively close to the observer, whose Earth-based line-of-sight through the atmosphere is limited to roughly a few hundred miles. If seen from space, the waves would follow the curved surface of Earth just as they follow the curved surface of the Moon.

6) The great variability of wave speeds for all wave videos (14 miles/sec to 110,000 miles/sec) is best explained as a parallax effect. The apparent speed is because the assumed length scale is for objects a great distance away. The speeds are much lower and more consistent if the assumed location is within the atmosphere.

Two Atmospheric Models

Two theoretical models are proposed to explain the wave pairs. The first assumes that they are due to the disturbance of a passing aircraft, flying in the lower atmosphere. The second assumes that they are plasma related, occurring in the upper atmosphere. The mechanism in both models is actually the same, with the wave energy coming from either jet fuel or from naturally available electricity.

Observations supporting the first model are:

7) Most modern commercial aircraft have two engines which leave a twin trail of exhaust plumes along the flight path.

8) The heated gases emerging from these high-powered engines rises due to buoyancy in the much colder air, particularly at cruising altitude (nominally 10,700 m or 35,000 ft).

9) The motion of the rising double plume behaves very much as a weather event, where a cold air mass chases a warm air mass. This well-documented physics is known to produce a sharply-defined frontal system, typically with high wind speeds and sometimes a line of thunderstorms.

10) By analogy, the double wave is observed because of the different indices of refraction of the cold air chasing the rising hot engine gases and forming a double front. A convincing lunar wave effect has been observed repeatedly in video recordings a few seconds after an aircraft crosses the face of the Moon during takeoff (see Crosswind, https://www.youtube.com/watch?v=7tLziSDYFiw&list=PLGmb5hq75WPw3OGplHLlsU7KnIlkctnfE), Fig. 5.

11) The wavefront is always parallel to the flight path of the aircraft, consistent with the orientation of the exhaust plumes.

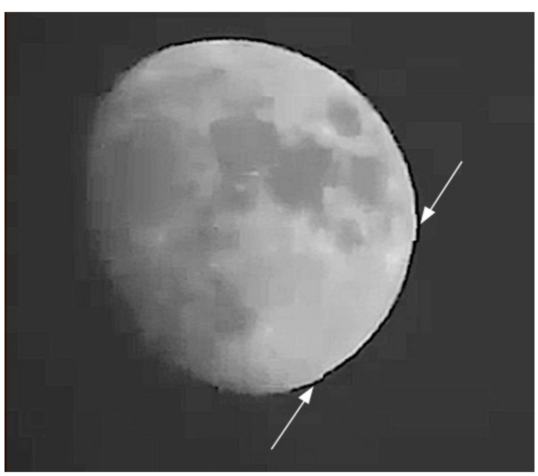

Fig. 5 Enhanced still frame from video showing aircraft induced refractive wave. (credit: DazzaTheCameraMan, https://www.youtube.com/watch?v=HIk03MKdhig)

Observations supporting the second model are:

12) A number of plasma-related phenomena, such as the *aurora borealis* (northern lights) are known to exist in the ionosphere. There is plenty of naturally occurring electrical power available to support wave creation and propagation.

13) The waves appear at the same time (+/- a few minutes) as planetary conjunctions, eclipses, sunrises, sunsets, equinoxes, and solstices. It suggests the trigger may be electrical, travelling at the same speed as the light recorded by the wave observers. Plasma, by definition, is electrically charged and therefore sensitive to electromagnetic disturbances in the cosmic forces.

14) A possible mechanism for the triggering pulse is the Barkhausen effect. The physics typically involves a line of magnetic force suddenly adjusting position in space as it passes by an anomaly embedded within a material. The sudden adjustment generates an electromagnetic pulse which can be measured some distance away.

15) By analogy, as two planetary bodies form an alignment with Earth, one or both of their magnetic fields may possibly be seen to adjust suddenly at the time of conjunction. The resulting powerful planetary-scale pulse would certainly affect Earth's magnetosphere and ionosphere, which could then amplify the pulse by several orders of magnitude.

16) As with the rising hot engine exhaust of the first model, an electrical discharge triggered by a cosmic pulse could heat the upper atmosphere plasma sufficiently to cause a refractive double wave to be detectable.

A mechanism to explain the image shift of lunar craters, as the waves pass by, is outlined in the next section. It applies to both of the models above.

Refractive Index Model for Image Shift

From the presumed location in Earth's atmosphere, it follows that the moving wavefronts are made of heated gas acting as lenses, causing a ripple effect to move over the image of well-lit background objects such as lunar craters. To account for the double shift of the image, there must be at least three distinct regions within a layer (or in closely spaced layers) separated by two wavefronts passing by the observer. Each of the moving wavefronts would have a difference in gas density, causing two different indices of refraction to operate.

Almost all known results have been from observers in the northern hemisphere. Since the Moon and other solar system bodies are located essentially in a plane, those observers will be looking southward with either an eastward (moonrise) or westward (moonset) component.

Fig. 6 shows light rays coming from a background celestial object and passing through the atmosphere. A single wavefront between gases of two differing densities is shown moving north to south, which is in an opposing direction to the incoming light rays from the southern sky. Due to a difference in the refractive index of the two regions, a shift in the position of the background image is observed as the wave passes by.

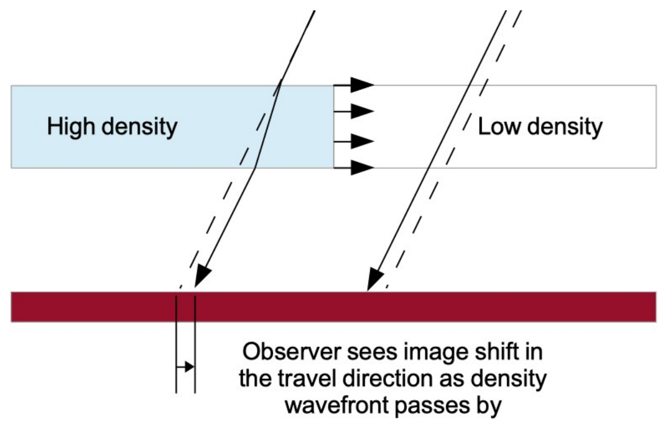

Fig. 6 A refractive index model to explain the observed ripple effect where a background object appears to shift in the north-to-south direction of wave travel.

17) In terms of the first model, the majority of aircraft runways and service routes lie in an east-west direction, so the hot gas plumes will lie in that orientation and be seen to drift north or south with the prevailing wind.

18) In terms of the second model, the general north-south direction of travel of the waves means they usually track parallel to the lines of the planetary magnetic field rather than across the lines.

The two proposed models must be tested for accuracy, since the atmosphere is affected by both rising hot air and by energies in the magnetosphere and beyond. It is possible both theories are correct, with the first explaining the predominant mechanism in the high-traffic airways near major metropolitan centres and the second being more relevant elsewhere.

PART 2 – Experiment to Determine the Wave Speed and Altitude

Two-Observer System

So far, only individual observers have reported isolated wave events. However, if two or more observers record a single event, important data can be obtained.

Figs 7 to 10 show a two-observer system with 3 cameras that can determine the ground speed, direction and altitude of the lunar waves. Fig. 7 is a plan view of the waves passing at an angle θ_{wave} past two observers A and B, located a known distance apart *d*. They simultaneously video record the Moon, which is much further away than distance *d*.

Fig. 8 shows the altitude *h* of the waves and the fields-of-view of observers A and B as they look at the distant Moon.

Fig. 9 shows a cross-section of the field-of-view of a single observer cutting through the atmospheric layer in which the waves travel. The circle is what is seen looking through the telescope, but in the plane of the wave layer, the field-of-view appears as an ellipse.

Fig. 10 shows the final graphical position of the elliptical field-of-view, allowing θ_{wave} to be known.

The two telescopes (or cameras with telephoto lenses) will closely track the Moon over periods of several hours per night in the hope of capturing a wave event. The video camera clocks must be synchronized for accurate time measurements.

A third wide-angle camera simultaneously video records the general vicinity of the Moon. It may be located at A or B and will allow verification of the direction and timing of any aircraft appearing to pass near the Moon. Since this camera will operate at nighttime, possibly a time-lapse function will increase sensitivity so distant aircraft navigation lights can be detected.

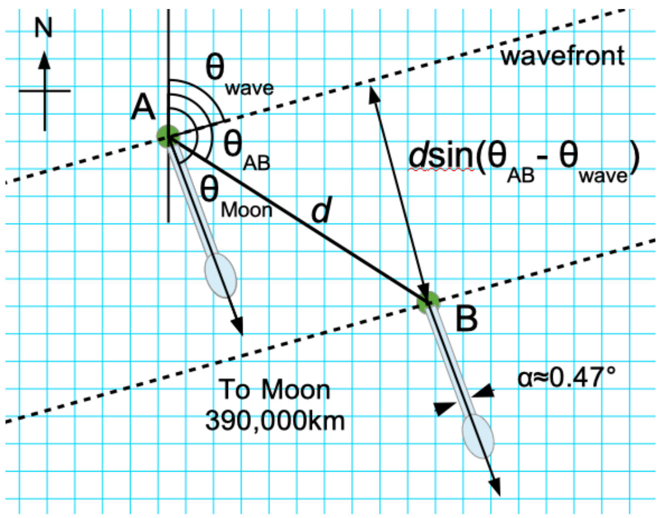

Fig. 7 Plan view of two observers at A and B with wavefront angle θ_{wave}, observer station angle θ_{AB} and Moon compass direction θ_{Moon}.

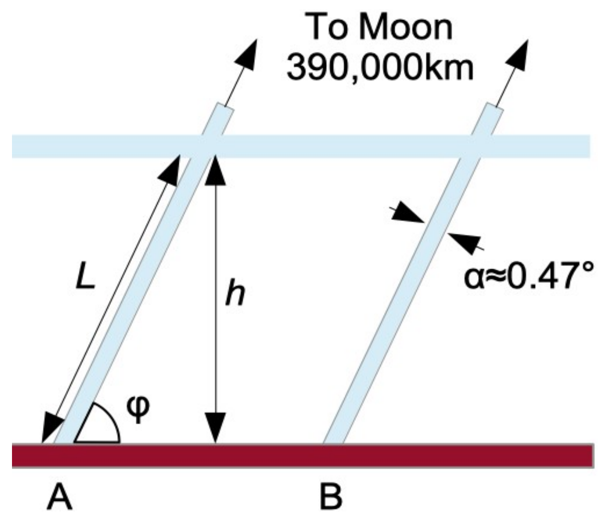

Fig. 8 Elevation view showing fields-of-view of two observers at A and B with wave altitude *h*. The Moon azimuthal angle is φ and the field-of-view angle $\alpha \approx 0.47°$.

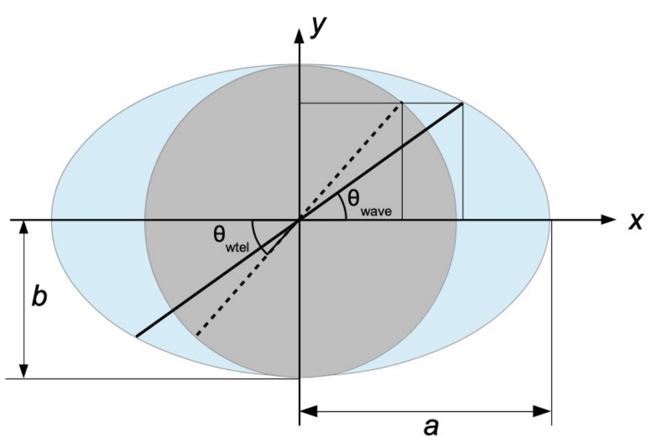

Fig. 9 A cross-section of the field-of-view comparing the telescope image (circle and dotted wavefront) with the elliptical shape and true wavefront orientation as seen in the wave layer.

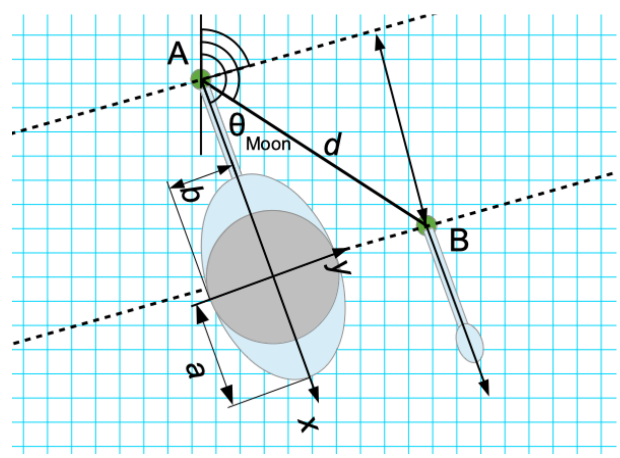

Fig. 10 The final map orientation of the elliptical shape and true wavefront as seen in the wave layer, yielding θ_{wave}.

Basic Methodology

Before setting up and using the two-observer system, it is worth mentioning a proven strategy to video record the Moon. CRROW 777 recommends shooting relatively wide, meaning the frame is typically filled with about about half of the face of the Moon and preferably at least some of the lunar rim. Often, the clearest indication of a wave is a disturbance seen in the continuity of the rim. If shooting in HD video, a digital zoom of 2x or 3x can be applied later to see details more clearly.

Some camera panning motion is also suggested as this proves the angled waves move at an independent speed and in an independent direction from the camera, thus are not artifacts of the recording system.

The task of measuring wave speed and altitude accurately requires a thorough understanding of the 3-dimensional situation. To avoid complex mathematical formulas, a graphical approach is recommended to determine critical angles where possible. This should provide an overall accuracy of better than ±3.6° (±1% of a full circle).

When the recordings of the 3 cameras are to be analyzed, a methodical 12-step process is followed to obtain the desired data:

a) Create an accurate map showing positions A and B, Fig. 7, with compass direction θ_{AB} and distance d.
b) Obtain still frames of the waves from the video recordings and enhance as needed.
c) Determine the raw wave angle θ_{video} from the still frames (overlay a line for clarity, as Fig. 1).
d) Determine the exact times of observation t_A and t_B from the video time codes to the nearest frame (1/60 second for HD video). Where possible, note the initiation time at A for each wave t_{A1i} and t_{A2i} and the termination times t_{A1t} and t_{A2t}. The initiation time at B for each wave is t_{B1i} and t_{B2i} and the termination times t_{B1t} and t_{B2t}.
e) Determine the Moon heading θ_{Moon} and altitude φ at the time of observation from an astronomical data source (eg., https://www.timeanddate.com/moon/).
f) Obtain the angle-of-view α and Moon libration angle θ_{lib} for the hour of observation from an astronomical data source (eg., Goddard Space Flight Center, https://svs.gsfc.nasa.gov/5187).
g) Superimpose the scaled and rotated video still frames onto the reference Moon image (also from Goddard) for the hour of observation so the alignment of the images is as exact as possible.
h) Determine the video frame rotation angle θ_{vframe} from item g).
i) Determine the actual tilt of the Moon θ_{tilt} relative to the horizon (see details below).
j) Calculate the true wavefront angle θ_{wave} using the circle-to-ellipse conversion formula.
k) Calculate the ground speed of the waves.
l) Calculate the altitude of the waves.

Detailed Procedures

In the list of procedures above, the items f) to j) require a more detailed explanation. There are 4 angles required to get the correct tilt of the Moon relative to the horizon at the time of observation, thus the correct telescope wavefront angle. There is then a conversion to find the true wavefront compass angle θ_{wave} in Fig. 7.

For item f), the Moon undergoes a monthly motion known as libration, during which it also appears to change size. The libration angle θ_{lib} and apparent Moon size α for each hour of each year is published on-line.

For item g), it will be necessary to use graphics software to superimpose a video still frame onto the reference image of the Moon for the time of observation. This will typically involve adjusting the size of the still frame, possibly flipping the image horizontally and/or vertically, and rotating the image to obtain the closest match possible. Every telescope and camera configuration will be different and some may involve a mirror or prism or other arrangement that inverts the recorded image, which must be corrected for a proper match. An example of the final result is in Fig. 11.

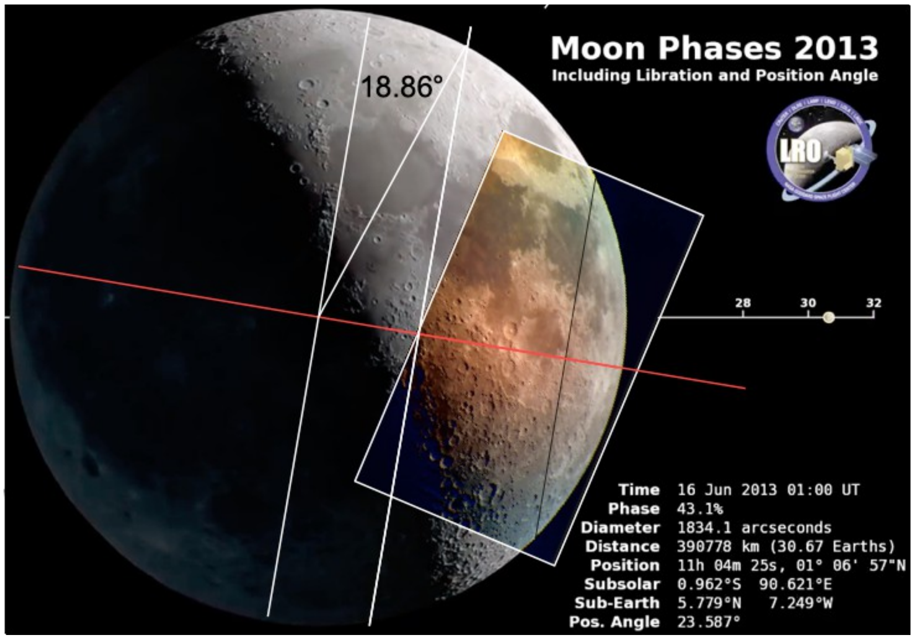

Fig. 11 Example of a video still frame matched to the Moon reference image from Goddard. The thin black line highlights the wave. The red line indicates travel direction away from the rim. The video frame only included 33.8% of the Moon diameter, so t_{A1t} was estimated by geometric means. (video credit: James Hannon, https://www.youtube.com/watch?v=T_2sOBISBHc)

For item h), the rotation of the video still frame θ_{vframe} in item g) can be obtained from the graphics software. Note that the reference image of the Moon is kept exactly the same as supplied (by Goddard), since it already takes the libration angle θ_{lib} into account.

For item i), a tilt angle θ_{rot} due to Earth's rotation at the time of observation must be determined. This rotation constantly changes the observer's orientation relative to the Moon minute by minute, and so knowing the exact time of the observation becomes important.

To calculate θ_{rot}, it is necessary to know the Moon position relative to due south (for an observer in the northern hemisphere). Due south is the location where $\theta_{rot} = 0$, so the correction is zero. The moon appears in the sky with no difference in tilt from the reference image (of Goddard).

The time when the Moon is at due south t_{south} for a given date and location may be found from an astronomical data source (https://www.timeanddate.com/moon/), Fig. 12.

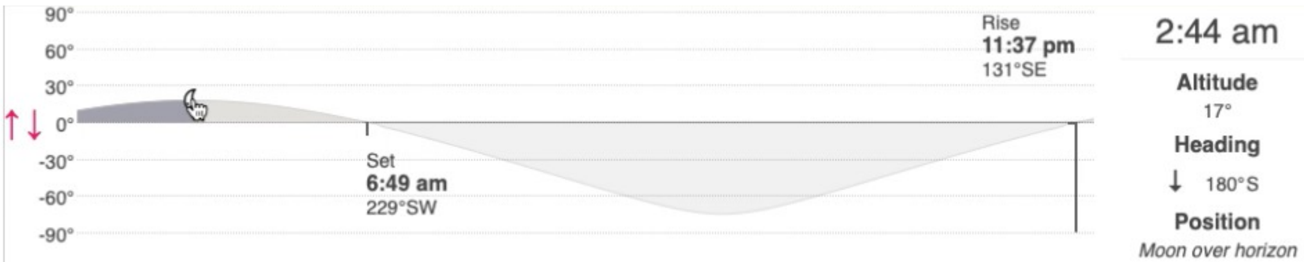

Fig. 12 An on-line finder for Moon altitude φ and heading θ_{Moon} at a given time and location.

The Earth rotates at the rate of 1 degree every 4 minutes, so the Moon appears to move at a very similar rate from the east (moonrise) to the west (moonset). Taking the difference between the time of observation and t_{south} (in minutes) gives the angle θ_{rot} in degrees:

$$\theta_{rot} = (t_{A1i} - t_{south})/4.13$$

where negative values correspond to a counter-clockwise tilt and positive values correspond to a clockwise tilt. The total tilt angle of the wavefront relative to the horizon θ_{wtel}, as seen through the telescope, Fig. 10, becomes:

$$\theta_{wtel} = \theta_{video} + \theta_{vframe} + \theta_{rot} + \theta_{Moon}$$

As suggested in the section above and by Figs 7-10, this equation may be satisfied using graphical software to apply and display all of the correct rotations to the images without resorting to complex mathematical formulas.

For item j), To determine the true wavefront compass angle θ_{wave}, there is a formula to convert the circle of Fig. 9 to an ellipse, so the true wavefront orientation can be known. By definition, an ellipse is the curve that follows the formula:

$$1 = X^2 + Y^2$$

where the x-y graph coordinates are scaled to $X = x/a$ and $Y = y/b$ and the ellipse semi-axial lengths are a and b, Fig. 9. For the current purposes, the semi-axis a is $\alpha/2\sin\varphi$ and b is $\alpha/2$, hence $b/a = \sin\varphi$.

To convert the telescope wavefront angle θ_{wtel}, the relation $\tan\theta = y/x$ is used. When stretching the x-axis to make the circle into an ellipse, it extends that axis by a factor a/b, while not changing the y-axis. The conversion becomes:

$$\theta_{wave} = \text{atan}[(b/a)(y/x)] = \text{atan}[\sin\varphi \tan\theta_{wtel}]$$

Wave Speed

Due to the effective separation $d\sin(\theta_{wave} - \theta_{AB}) = d\sin(\Delta\theta)$ between observers, there will be a time difference t_{AB} as the wave pair passes each station. Since the video cameras will have closely synchronized clocks, t_{AB} may be found by subtracting the time of wave appearance at A from the time of appearance at B. The ground speed v_{AB} of the waves is simply:

$$v_{AB} = d\sin(\Delta\theta)/t_{AB}$$

Wave Altitude

With the known wave speed, the altitude can now be calculated. Each observer will see the waves travel across the known angle-of-view of the Moon α in a time t_{Moon}. Since the Moon is at an angle φ above the horizon, the actual wave speed across the face of the Moon will be over twice the stretched semi-axial length, Fig. 9. Using the Pythagorean theorem to calculate that length:

$$b_{stretch} = [b^2\sin^2\Delta\theta + b^2\cos^2\Delta\theta/\sin^2\varphi]^{1/2}$$

or, substituting $b = \alpha/2$, the wave will travel over the stretched (elliptical) angle-of-view:

$$\alpha_{stretch} = \alpha[\sin^2\Delta\theta + \cos^2\Delta\theta/\sin^2\varphi]^{1/2}$$

Thus, the speed component seen by the telescope is $v_{AB}\alpha/\alpha_{stretch}$. From trigonometry, Fig. 8, the distance between an observer and the waves is:

$$\begin{aligned} L = (v_{AB}\alpha/\alpha_{stretch}\ t_{Moon})\cot(\alpha) &\approx 120\ v_{AB}\alpha/\alpha_{stretch}\ t_{Moon} \\ &\approx 120\ d\sin\theta\ t_{Moon}/[t_{AB}(\sin^2\Delta\theta + \cos^2\Delta\theta/\sin^2\varphi)^{1/2}] \end{aligned}$$

where the product $v_{AB}t_{Moon}$ yields a distance across the angle-of-view and a typical value of $\alpha \approx 0.47°$ was assumed. From Fig. 8, the altitude of the waves is $h = L\sin\varphi$, or in terms of the 6 variables:

$$h = d\sin\Delta\theta\cot\alpha\sin^2\varphi\ t_{Moon}/[t_{AB}(\sin^2\varphi\sin^2\Delta\theta + \cos^2\Delta\theta)^{1/2}]$$

Two Scenarios

In a hypothetical case based on the first atmospheric model, where $d = 0.03$ km (100 feet), $\Delta\theta = \theta_{wave}-\theta_{AB} = 90°$, $\alpha = 0.47°$, $\varphi = 45°$, $t_{Moon} = 10$ seconds and $t_{AB} = 3.6$ seconds, the wave speed would be about 8.3 m/s (28 ft/s) and the altitude about 7.18 km (23,900 feet).

In another hypothetical case based on the second atmospheric model, where $d = 0.3$ km (1000 feet), $\Delta\theta = \theta_{wave}-\theta_{AB} = 90°$, $\alpha = 0.47°$, $\varphi = 45°$, $t_{Moon} = 10$ seconds and $t_{AB} = 3.6$ seconds, the wave speed would be about 83 m/s (280 ft/s) and the altitude about 71.8 km (239,000 feet).

Further Steps

As of the date of writing, only items b), c) and d) have been applied to the data from about 20 lunar wave videos. The previous working theory assumed the waves were actually on the Moon or on other planetary bodies, so no system was devised until recently for determining the in-atmosphere wave direction, speed or altitude.

Once the database has been updated in terms of the current theories, the results and the theories of Part 1 will be posted as a Wikipedia entry for “Lunar Waves”.

The experimental procedure of Part 2 will be posted separately as a WikiHow entry, for those who wish to try out the two-observer system.